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ABSTRACT

A series of studies investigated the development of infants' understanding of the containment function of certain objects. In Experiment 1, infants' absolute preference for looking at either a can or a tube was tested. No preference was found. Two measures were used in Experiments 2 and 3. One assessed infants' looking response or gaze behavior directed to videotaped sequences of pouring behavior which were designed to establish habituation and reveal differences between a can and a tube. Another measure assessed infants' ability to imitate the dropping of cubes into a cup. In Experiment 2, infants 14 months of age were contrasted with 20-month-olds; results replicated a prior finding that older but not younger infants demonstrate an understanding of containment. The main study, Experiment 3, examined whether the understanding of containment could be acquired by 14-month-olds who were given training. A total of 50 infants were randomly assigned to 5 training conditions. These involved 4-week training with, respectively, container and cube; container only; tube only; ball only; and a laboratory visit conducted for the purpose of testing short-term training. Only one condition was effective in leading to the development of an understanding of containment. Infants 14 months old who played with both cans and tubes in their home for 1 month performed in both tests in a manner similar to that of untrained 20-month-olds. (Author/RH)

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CONCEPTUAL DEVELOPMENT IN INFANCY:

THE UNDERSTANDING OF CONTAINMENT

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ABSTRACT

Conceptual Development in Infancy: The Understanding of Containment

Piaget (1954) depicts knowledge as constructed through action upon the world, while Gibson (1979), argues for a knower capable of directly perceiving what the world affords. Recent research in infancy has demonstrated previously unexpected infant competencies. Substantially less explored is the development of infants' understanding of the functions of objects. One such concept, 'containment', was investigated in several experiments.

Two measures were used. After being habituated to videotaped episodes of sand being poured into and out of a cylinder, infants saw a "possible" event -- a container -- and then an "impossible" event -- an open-ended cylinder. Infants who understand containment were expected to look longer at the 'impossible' event. In the second test, infants were shown a game involving dropping blocks into a cup, and then asked to imitate it.

In Experiment 1, infants' absolute preference for looking at a can versus a tube was tested as a check for the habituation experiment. There was no preference. In Experiment 2, 14-month-olds were contrasted with 20-month-olds replicating a prior finding that the latter but not the former demonstrate an understanding of containment.

The main study, Experiment 3, examined whether the understanding of containment could be acquired by 14-month-olds. Fifty infants were randomly assigned to five training conditions. One condition was effective in leading to the development of an understanding of containment: Infants who played with both cans and tubes in their home for one month, performed in both tests similarily to untrained 20-month-olds.

INTRODUCTION

If indeed it is the case that much of the world, particularly the physical world, is directly and immediately understandable to infants, then it should be the case that even young infants will behave appropriately relative to the meaning of objects and events, rather than to their constituent parts (e.g., their form or color). Indeed according to the extensive research reviewed by Eleanor Gibson and Elizabeth Spelke (1983), this is what they do with simple affordances, such as support. Thus, the weight of evidence concerning the extraction of primitive affordances heavily favors the Gibsonian model. But equally clearly, our mature understanding of the nature of reality goes beyond these "simple" affordances and it is not clear that the developmental theory of transition to more complicated understandings will be similarly resolved. In fact, we have little empirical evidence on this issue.

In order to trace the cognitive development of infants beyond their direct perception of more simple affordances towards their increasingly sophisticated understanding of the functional properties of objects, we need to examine this transition empirically.

As adults, we know far more about objects than that they are permanent and solid, and retain their identity across spatiotemporal displacements. We can make accurate predictions about their functional properties (for example, as tools) and about their likely behavior, either alone or in relation to one another, and we are prone to categorize them with ease, either functionally or semantically. A complete account of cognitive development will thus rely crucially on understanding the transition from the basic object concept to these increasingly sophisticated understandings. It is precisely this question which is the focus of the work reported here.

General Methods for Studies 2 and 3

Stimuli. For the studies of looking time, 3 videotaped sequences were produced. The first of these was used in the habituation phase. Here, a woman is shown pouring sand into and out of a cylinder. The opening and sides of this cylinder are clearly visible, but the presence or absence of a bottom can not be visually determined. The pouring activity continues for 40 seconds. The end of an habituation trial was therefore signalled by either a one-second look-away by the infant, or by having reached 40 seconds of elapsed time without a look-away.

The second videotaped sequence was the test trial for can-revelation. The same woman pours sand into and out of a cylinder -- six seconds of the habituation tape. Following this she begins to rotate the cylinder end-to-end revealing both the open and closed ends. This "can-revelation" continues for 5.2 seconds. This pouring -plus-revelation episode constitutes a "can" segment. These segments were repeated continuously until the infant looked away for one second, or until a maximum of 100 seconds was reached. The third videotaped sequence was the complement test trial for the tube. In this sequence the woman reveals a tube rather than a can.

The materials for the "in vivo" test were 2 white styrofoam cups and 3 of the all- red WAIS-R Block Design cubes. One of the cups had its bottom removed, transforming it into a tube.

Procedure. Experiments 2 and 3 each consisted of two converging tests of concept acquisition. The first test employed a violation of expectancy paradigm. Infants were first habituated to videotaped episodes of sand pouring into and out of a cylinder whose bottom was obscured. Infants' fixation times were scored by a naive observer in another room. Infants continued to view these sequences until a cut-off criterion, a 50% reduction in their looking time from the mean of the longest two of their first three

trials, was met. This constituted the end of habituation and signalled the initiation of the test trials.

In the test trials, infants saw alternately either the can revelation or the tube revelation videotapes for four trials. The dependent measure was percentage of time that each infant looked at the tube revelation video:

$$TPCNT = (T1 + T2) / (C1 + C2 + T1 + T2).$$

Infants who possessed a concept of containment were expected to look longer at the violation object, the tube.

The second testing, labelled "in vivo", always followed the videotaped presentations because of possible order confounds. An experimenter, seated on the floor across from the infant, dropped 3 cubes into a cup and then rattled them. During this procedure, the experimenter was careful to conceal from the infant's view the bottom of the container. Following this, the experimenter spilled the cubes out onto the floor in front of the infant. The experimenter then presented two containers to the infant, one of which had the bottom removed. The experimenter showed these clearly to the infant while making eye contact through the bottomless cup. The infant was encouraged to pick up a cube (if s/he had not already done so) while the experimenter said, "Now, you do it (Jane)," and then lowered both cups directly in front of the infant. Left/right presentation of the cups was alternated throughout the six trials. Infants were scored as "correct" if they chose to drop the block into the intact cup, and as "incorrect" if they selected the bottomless cup. The dependent measure, INVIVO, was the proportion of "correct" (that is, regular cup) choices made by the infant.

Experiment 1: Testing the Assumption of Equal Preference

Purpose

One of the assumptions critical to the interpretation of infants' looking time in Experiments 2 and 3 is that there is no absolute preference between the test stimuli. The goal of Experiment 1 was thus to test this assumption of equal preference for looking at the videotape displays of the can and the tube.

Methods

Subjects. Participants were 14-month-old infants (N = 14, 8 of whom were female; mean age = 14 months, 3 days.

Stimuli. Two videotaped sequences were produced, using segments identical to those in the test trials of Experiments 2 and 3. In these segments, either a tube or a can was shown being rotated by a person in the videotape, toward and then away from the infant. This was done so as to reveal the can's one closed end and one open end, and the tube's two open ends. Six such segments were alternated in the two sequences. In one condition, Can First, the sequence was can-revelation; tube-revelation; and so on for the total of six trials. In the second condition, Tube First, the sequence was tube-revelation; can-revelation; and so on for the total of six trials.

Procedure. Following an initial warm-up phase, infants, who had been previously randomly assigned to either the Can First or the Tube First conditions, were shown the appropriate six-segment sequence. They viewed each segment to a one-second look-away, or to a maximum of 40 seconds per segment. The scores were recorded as total looking at each segment in the sequence.

Results

Total looking time at tube and total looking time at can were calculated separately for infants in each presentation order (Can First, N = 7, versus Tube First, N = 7). From these calculations, percentages of can looking time

(CLT) and tube looking time (TLT) were calculated for each group. For Can First, CLT = 55.3%, and TLT = 44.7%; for Tube First, CLT = 43.8%, and TLT = 56.2%. Combining the presentation orders, CLT = 50.4%, and TLT = 49.6%, which clearly indicate that these infants had no absolute preference for either the can or the tube. The average per trial looking time difference, in fact, is .4 seconds, which is in fact less than the resolution power of the scoring method.

Conclusion

Given the essential equivalence in looking time at the isolated can-revelation segment and the tube-revelation segment in this preference experiment, the use of these materials for the test trials in subsequent experiments is justified. Therefore, no adjustments to looking-times for the test data were made.

Experiment 2: Replication of the Age Differences in Performance

Purpose

The purpose of Exp. 2 was to determine the age differences in the two key tasks -- looking time as measured by TPCNT and cube dropping as measured by INVIVO.

Methods

Subjects. The first group was the attention-only control group (the Ball Only -- BO) group from experiment 3. There were 10 infants in the BO group, half of whom were female (mean age = 14;22). The second group consisted of 10 untrained 20- to 21-month -old infants, half of whom were female (mean age = 20;24).

Results

ANOVAS of TPCNT:

No effect for sex, nor interaction.

Effect of age, 20-month greater than 14-month, $p < .001$.

ANOVA of INVIVO

Effect of age, 20-month greater than 14-month, $p < .001$.

Conclusions

In both tasks, 20-month-olds clearly displayed an understanding of containment, by looking longer at the violation event -- the tube revelation -- and by more often choosing to drop the block into the intact cup. In contrast, the 14-month-olds neither looked longer at the tube, nor discriminated between the cup and the tube when dropping the block in the 'in vivo' test.

Experiment 3: Can the Understanding of Containment Be Trained?

Purpose

A short-term but realistic training experience, combined with additional experimental contrasts to attempt to sharpen the issue of what features are necessary for infants' acquisition of the concept of containment.

Methods

Subjects. Research participants were 50, 13-month-old infants, half of whom were male, who ranged in age from 13 months, 2 days to 13 months, 28 days-of-age when they began training. Forty such subjects were randomly assigned to one of four training conditions (CT - container and tube, TO - tube only, CO - container only, and BO - ball only) with the constraint that the genders were equally represented in each group. After completing four weeks of training in the home, these infants came to the

laboratory for testing. The mean ages of each group at test were: CT = 14;26; TO = 14;21; CO = 14;21; and BO = 14;22. An additional 10 infants, half of whom were boys (mean age at test = 14;25) were assigned to a fifth condition (LV - laboratory visit).

Materials for training. The materials for the CT group were two white, opaque plastic cylinders, each of which was 5.5 inches high and 4.5 inches in diameter. One of these cylinders -- the tube -- was open at both ends; the other -- the can -- had one open end and one closed end. In all other ways, the cylinders were identical. The TO group received only the tube. The CO group received only the can. The attention-control group -- BO or ball only -- received a solid white rubber ball about 2.5 inches in diameter. The LV group played with both the can and the tube, described above, in a sandbox in the laboratory for about ten minutes.

Procedures. During a home visit, the experimenter demonstrated playing with the appropriate toys and left written instuctions. The laboratory visit (LV) group followed a different procedure. Each of these infants made two visits to the laboratory, one for training and one for test. In the first visit, they played in a sandbox with the same can and tube as the CT group. Mothers played with their infants, following the same procedures as the CT group. The only difference, of course, is that these infants played with the same material (that is, sand) which would be used in the videotaped test stimuli. The goal for this group was to check
if direct training to test might be equally effective as longer-term training at home. Within one week following training, the LV infants returned for the same test as the other four groups.

Results

ANOVA of TPCNT:

Main effect of experimental group membership, $p < .05$.

POST HOC TUKEY:

CT > BO (control), $p < .05$.

ANOVA of INVIVO:

Main effect of experimental group membership, $p < .05$

POST HOC TUKEY:

CT > BO (control), $p < .05$.

See Figure for results of both Experiments 2 and 3

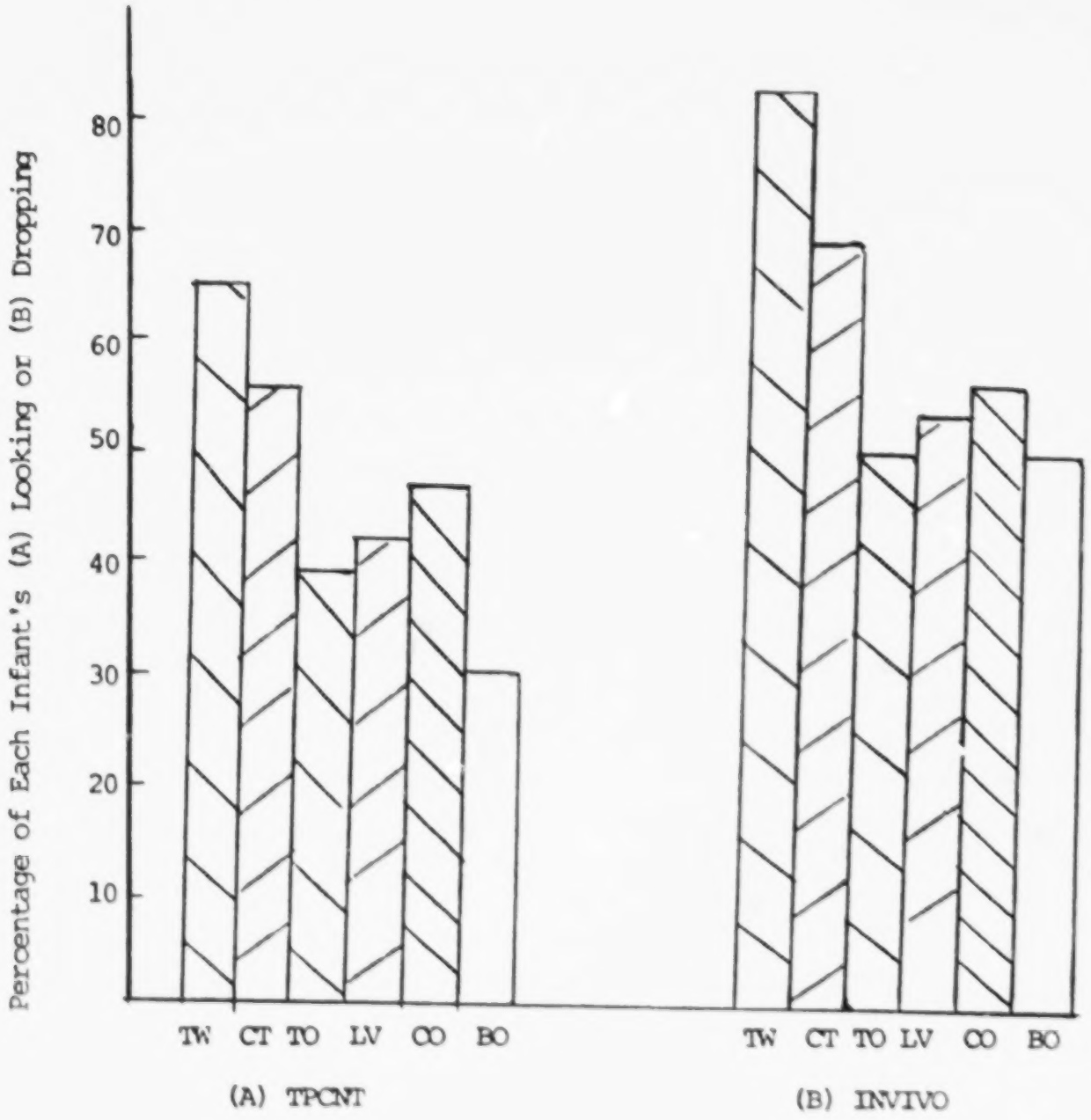
OVERALL CONCLUSIONS

1. In the analyses of infant looking time, it was shown that the CT group was significantly different from the attention- only control group (BO). The other training groups occupied an intermediate position -- not significantly different from either CT or BO.

2. This same pattern of results was obtained with the 'in vivo' test.

3. When 20-month olds are included in the analysis, the pattern of means on both tests was 20-month-olds > CT, and CT > than BO. On Post Hoc tests, however, the 20-month-olds and the CT groups were not significantly different from each other; both significantly outperformed the BO group.

4. Realistic and ecologically sensitive intervention studies, which focus infants' attention over a reasonable period of time on a particular content, may serve to demonstrate which aspects of conceptual understanding are amenable to change. Such investigations will help to draw more clearly the connections between the origins of knowledge in early infancy and their mature expressions later in development.



Figure

Proportion of (A) Looking Time at Tube (TPCNT) and (B) Dropping into the Can (INVIVO), Each Trained 14-Month-Old Group and Untrained 20-Month-Olds

Container Videotaped Looking Sequence

Step 1: Habituation tape trials

Presentation 1: Until 1-sec look-away, or 40-sec maximum.

Presentation 2: Until 1-sec look-away, or 40-sec maximum.

Presentation 3: Until 1-sec look-away, or 40-sec maximum.

Step 2: Habituation criterion:

Mean of the longest 2 trials of Presentations 1, 2, 3 = Z.

Habituation criterion (C) = .5(Z).

2 consecutive trials occur with looking times < C = End of habituation.

Step 3: Habituation phase maximum:

Presentations of habituation tape continue until criterion (C) is met.

(To avoid infant's fatigue, an a priori maximum of 12 habituation presentations is imposed. Data from infants not reaching criterion within 12 trials is not used.)

Step 4: Test tape trials, in fixed sequence:

Can 1: Until 1-sec look-away, or 100-sec maximum.

Tube 1: Until 1-sec look-away, or 100-sec maximum.

Can 2: Until 1-sec look-away, or 100-sec maximum.

Tube 2: Until 1-sec look-away, or 100-sec maximum.